SOIL SURVEY OF THE MORTON AREA, NORTH DAKOTA,

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DESCRIPTION OF THE AREA.

The Morton area comprises 544 square miles of territory near the southern border of the State of North Dakota and west of the center. The area is rectangular in shape and embraces 16 townships, namely, Townships 131 and 132 north and Ranges 85 to 92 west, inclusive. About three-fourths of the area lies in Morton County and the western side includes a portion of Hettinger County and a small part of Adams County. The southeastern corner of the area takes in about 1,750 acres of the Standing Rock Indian Reservation.

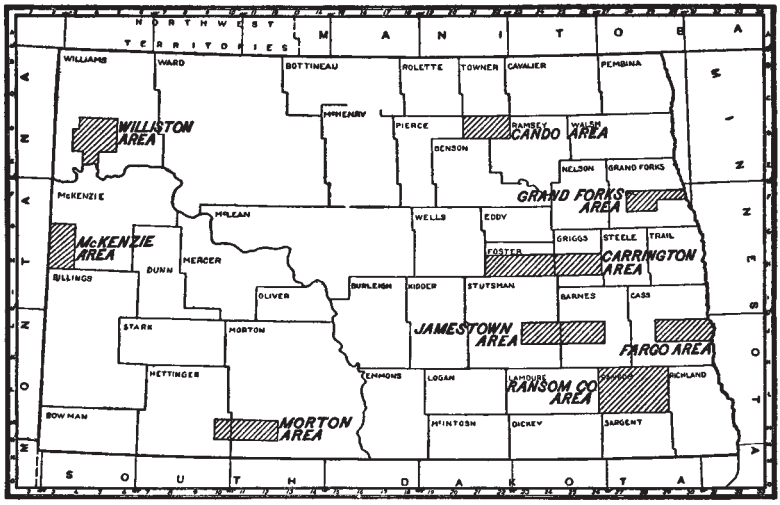

FIG. 28.—Sketch map showing location of the Morton area, North Dakota.

The entire area lies within the drainage basin of the Cannon Ball River, which enters the northern border of the rectangle about midway of its length from east to west and flows in a southeasterly direction toward the southeastern corner. Cedar Creek, a large tributary of the Cannon Ball, sometimes known as the South Fork of Cannon Ball, flows south of the border of the area and parallel to it for a long distance, entering the area in the southeastern corner, and empties into the Cannon Ball. The Cannon Ball continues its course eastward and empties into the Missouri. The local drainage of the

Morton area is effected by numerous small water courses which pursue parallel courses toward the Cannon Ball or the Cedar. They are all intermittent in character, and, with the exception of a few of the largest, become dry after a few weeks of dry weather. The streams fed by springs have pools of standing water along their courses even during protracted droughts, though no stream, except the Cannon Ball and Cedar, will flow after weeks of dry weather.

This region, in common with the whole of southwestern North Dakota, is a great plateau, elevated to a height of nearly 2,000 feet above sea level and more or less carved and modified by the forces of weathering and erosion, to which it has been exposed for ages. The great ice sheet which scoured across the northern part of the State and so greatly influenced the topography did not extend this far south, and the only evidence of ice action in this area is the beds of gravel on some of the higher hills in the eastern part, north of Wade, which were brought down by the outwash from the front of the melting ice.

There are two main topographic divisions, the stream valleys and rolling upland. Along the larger streams, as the Cannon Ball, there are alluvial flats built up by the streams in times of overflow. They are in many cases only a few feet above the present level of the stream and are subject to flooding at frequent intervals. Above the lower flats are a number of imperfectly defined terraces, successively occurring at higher levels until the high plateau is reached. The entire belt of alluvial land in the several terraces is rarely more than 1 mile in width.

The character of the upland is dependent upon the amount of erosion that has taken place. The small streams and drainage courses have as a rule cut out broad, gently rolling valleys, well suited to farming. Near the origin of these streams there are frequently areas several square miles in extent where good drainage has not been established but where the land can easily be drained by ditching. Away from the streams the country ranges from gently to sharply rolling. In a few small areas where the streams have cut rapidly through soft shales and sandstones a topography has been developed typical of the semiarid plains and known in North Dakota as "Bad Lands." Steep slopes, flat-topped buttes, and narrow alkali flats characterize these localities. Such areas are generally useless for farming, but make excellent land for grazing. The total amount of such land in the Morton area amounts to only a few square miles. The most extensive topography is that of the rolling upland, which covers wide stretches of country.

The most prominent features of the landscape are the high hills or buttes that rise above the general level of the region and serve as landmarks that can be seen for long distances. These hills are of two

types: The flat-topped buttes, of which the Coffin Buttes are a good example, and the steep hills thickly covered with chert and sandstone fragments, as in the case of Pretty Rock Buttes.

The present population in this part of North Dakota is composed of two classes, whose interests are to some extent antagonistic. The ranchers or cattlemen comprise one class. They are the pioneers of the region, who pushed out even before the country was safe from the Indians, and at first led a rough life caring for their herds of horses and cattle. Within the last few years has come in the second class, composed of homeseekers from the older States, who have homesteaded upon public land, built houses and barns, and turned the region from a grazing to a farming country.

The new settlers have come largely from Iowa, Wisconsin, and the eastern part of North Dakota. They are not entirely unfamiliar with the conditions that they encounter and expect to undergo many hardships before they make a success. There is also quite a number of foreigners, Norwegians, Germans, Hungarians, and Russians, but the most of them have had experience farther east before coming to this area.

There are as yet no towns in the area and no settlements of any size. It is not likely that any towns will grow up until the proposed line of the Northern Pacific Railroad is built through the area and the townsites are located to suit the conditions that arise. There are at present four post-offices in the area, two of which are volunteer offices. Wade is one of the oldest and best-known places in the area.

The Morton area at the present time is poorly provided with transportation facilities, and if there was no prospect of improvement in the means of getting agricultural products to markets the outlook for general farming would be very gloomy. Until the present year all products not consumed in the area were shipped by the Northern Pacific Railroad from Mandan, Glen Ullin, Richardton, and other points. This necessitated a haul by wagon of 55 to 75 miles. During the summer of 1907 the Chicago, Milwaukee and St. Paul Railway opened a line 12 to 20 miles south of the border of this area, and there seems to be little doubt that the Northern Pacific Railway will in the near future build a road through the area. Surveys for this purpose have already been made, and the general impression is that the road will soon be built in order that the company may secure the land granted by the government. The long haul necessary at the present time makes it unprofitable to grow the ordinary agricultural products, but there has been a good local demand for potatoes, oats, and other feed stuffs. The railroad construction camps have taken large quantities of these products, and the new settlers have for a time had to buy enough to live on while making the first crop.

Cattle and sheep are shipped by the carload to the Chicago and the St. Paul markets. They are driven in large herds to the nearest railroad shipping point. Before the completion of the new road to the south of this area Mandan handled the greater part of this traffic, but during 1907 large shipments have been made from Lemmon, on the Chicago, Milwaukee and St. Paul Railway.

The area is abundantly provided with cheap fuel in the lignite deposits that outcrop over the upland. The lignite beds are sometimes 6 to 14 feet in thickness and furnish a good fuel for domestic purposes. Only the thickest and most accessible of these beds are now worked, but these are of such frequent occurrence that no settler is more than a few miles from a good mine.

CLIMATE.

The following table, compiled from the records kept at Glen Ullin and at Dickinson, show the normal monthly and annual temperature and precipitation for these places. While both of these stations are north of the Morton area, their climatic conditions are so nearly the same that these figures may be considered as representative of the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Glen Ullin.		Dickinson.		Month.	Glen Ullin.		Dickinson.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	In.	°F.	In.		°F	In.	°F.	In.
January	12.2	0.35	10.3	0.40	August	66.8	2.46	67.8	0.97
February	10.4	.45	11.7	.41	September	56.7	1.54	57.0	.60
March	22.8	.80	23.5	.96	October	44.3	.....	44.2	.89
April	41.9	.63	42.6	1.83	November	28.0	.36	26.8	.56
May	52.0	1.66	52.8	2.34	December	17.5	.43	19.1	.40
June	62.1	2.72	61.1	2.23					
July	68.1	1.33	68.5	2.37	Year	40.2	.....	40.4	13.96

The area, in common with the whole of the high plateau of Montana and the Dakotas, is subject to wide variations in temperature. The periods of extreme heat in summer never last longer than a few days at a time, and the nights are nearly always cool. The cold periods in winter are more extended. The mercury may stand below zero for days or weeks at a time, frequently dropping to −30° F. or lower. The uniformity of the cold and the dryness of the atmosphere, however, make the winters in this region much more endurable than over a large part of the United States where alternate freezing and thawing take place and a damp atmosphere adds to the unpleasantness and danger of the climate. In this region the snowfall in ordinary winters is light and soon blows off the hills. Cattle

and sheep are expected to graze all the winter and little provision is made by the ranchers for feed and shelter. With ordinary care the losses are surprisingly small. Heavy losses are occasioned by heavy snowfall when there is no wind to clear it off the grazing land, but a reasonable preparation for such emergencies would entirely obviate these losses.

The table given below shows the dates of the first and last killing frosts for a period of seven years.

Dates of first and last killing frosts.

Year.	Glen Ullin.		Dickinson.		Year.	Glen Ullin.		Dickinson.	
	Last in spring.	First in fall.	Last in spring.	First in fall.		Last in spring.	First in fall.	Last in spring.	First in fall.
1899.....	June 1	Sept. 19	May 17	Sept. 18	1903.....	May 5	Sept. 12	May 20	Sept. 4
1900.....	May 4	Sept. 15	...do	Sept. 16	1904.....	May 14	Sept. 13	May 14	Sept. 11
1901.....	.....	.....	May 7	Sept. 17	1906.....	May 27	Sept. 29	May 26	Sept. 26
1902.....	June 21	Sept. 12	May 26	.....	Average.	May 22	Sept. 17	May 18	Sept. 15

It is a rare occurrence that much damage is done by frost before the middle of September, and it is usually several weeks later before vegetation is seriously affected. It will be seen by the records that these stations have an average of 118 and 119 days, respectively, free from frost, which is amply sufficient for the crops usually grown in this latitude. There has been considerable discussion as to whether corn could be profitably grown in the season free from frost. Many of the new settlers coming from corn-growing States have attempted to grow corn here. It has been clearly proved the slowly growing varieties have little chance of coming to maturity, but there has been a gratifying improvement in the early varieties, and in ordinary years these may be successfully grown. The growing of corn to cut green for feed, however, is entirely feasible and commendable.

The greatest climatic problem in this area and one upon which the future of the country depends is that of rainfall. For a long time this part of North Dakota was classed with the semiarid plains and was considered beyond the limits of safe farming. Records for nearly thirty years show that in that time there were several years during which the rainfall was insufficient to grow crops and many years of scanty precipitation. The records given above show for this region the scanty annual average of less than 15 inches of rain. For the last five or six years there has been sufficient rain during the growing season to produce good crops, and this has given an erroneous impression to the new settlers as to what may be expected in the future. There has spread the idea that climatic conditions have permanently changed, and this is attributed by some to the settlement of the region and the plowing of land. While there is no foundation for this belief,

the records show that the years of deficient rainfall are of rare occurrence and the average of good years is sufficient to make farming profitable. The good farmer will not involve himself financially so that one dry year will bankrupt him, and he will in his farming use the most approved dry-farming methods in order to make the best use of the moisture he has in the soil. If he will take these precautions there is no reason why he should not be very successful in the long run and hold an average of profits from his farming equal to those of the farmers in almost any other general farming section.

AGRICULTURE.

The conditions that prevail in this part of North Dakota are those of a country changing its system of agriculture from grazing to farming. Until within the last few years the only settlers were ranchers, living along the stream courses at intervals of several miles. Many of these ranchers came in as soon as the country was opened up and grazed their cattle upon the vast stretches of public land. The excellent pasture, hay, and water made this industry very attractive, and a good living—in some cases a moderate fortune—was gained by the cattlemen at a minimum of expense and labor. Too much praise can not be given these pioneers as a courageous and hospitable people, but the cattle business did not develop the agricultural resources of the country. In rare cases the ranchers sowed oats and feedstuffs, but in most cases they cut enough of the native prairie grass to carry their live stock through the worst of the winter. As already stated, for a long time the impression prevailed that farming could not be successfully carried on in this region with its average rainfall. A succession of years of abundant rainfall, however, caused a great rush of settlers into the whole of the semiarid region and it was inevitable that the good land along the Cannon Ball River would not long be neglected. The spring of 1906 saw very few settlers of the permanent farming class in this area, but in less than two years the country has been thickly dotted with farmhouses and practically every quarter section of public land that would possibly produce a living for a family has been taken up.

The first crops attempted by the new settlers are "sod" crops of wheat, oats, and flax, and potatoes and other vegetables for home use. On account of the long distance to market flax, and, in many cases, wheat, were not profitable crops. Oats, potatoes, and feedstuffs found a good local demand during the last year, as many of the new settlers were compelled to buy these commodities while they were growing their first crop. The summer of 1907 was favorable, and the farmers that were fortunate enough to get in crops had good returns.

None of the farmers as yet have planned any system of crop rotation or method of farming. These things will come later when they have become more accustomed to their land and climate.

Labor has been fairly abundant, as many of the homeseekers were without means and were compelled to earn their living while proving up their claims. It is a common custom for the farmers to exchange work during the busy seasons, when it is desirable that a number of hands should hasten the work.

A very small part of the land is now under private ownership. About one-third of the land in the Morton area, comprising the odd-numbered sections over a large part of it, is owned by the Northern Pacific Railroad Company, having been obtained by a grant from the Government on condition that the company construct a line to furnish transportation to this part of the State. This land has not yet been placed upon the market for sale. The greater part of the remainder of the area is public land. While homestead entry has been made upon all the desirable land, very few of the homesteaders have as yet obtained title, but many will prove up in a short time. No land has been sold recently in the area, but the farming land is valued at $8 to $15 an acre and the rougher grazing land at $2 to $8.

In North Dakota the farmers are not compelled to fence against cattle, but while the ranchers have been much inconvenienced by the sudden influx of settlers, both sides have exercised patience and no trouble has resulted. Although it will be many years before the cattle business will be entirely broken up, the present system of large ranges will in the end have to be abandoned. It is certain, however, that this will always be a mixed farming and grazing country. It would be a wrong system of agriculture that did not utilize the large area of rough land which affords such excellent pasturage. It would be well for all farmers to take up the raising of live stock as early as possible, so that they will not have to depend entirely upon the farming when dry years come. Horses and sheep are especially profitable. They could be herded by the farmer or his family on the public range when there is no other work to be done, and in busy seasons they could be pastured.

SOILS.

In order to understand the topography of the western part of North Dakota and the reasons for the diversity of the rock formations and the present position of the soils, it is necessary to know something of the geological history of the region. The whole of the Morton area is upon what is known as the Missouri Plateau, a great region now elevated to a height of 1,800 to 2,000 feet above sea level. This plateau is composed of nearly horizontal strata of sandstones, limestones, and

shales, with beds of carbonaceous matter and lignite coal known as the Laramie formation. It is quite natural that the materials composing the Laramie should vary in composition, since it represents the deposits on the shores and bottom of a vast brackish sea of Cretaceous time. That shallow brackish conditions and even swamp conditions prevailed is proved by the alkaline and calcareous composition of a large part of these rocks and the presence of the lignite that could only be deposited under swamp conditions. At the end of the Cretaceous period the region was elevated above sea level and the streams began their work of cutting their channels and eroding and carving the region. The great ice sheet that scoured over the northern part of the State during Glacial times did not extend its action this far south, but occasional drift bowlders were deposited and remain as gravel beds on the tops of some of the higher hills in the northeast part of the area.

The agencies of weathering and erosion have converted the sandstones, calcareous sandstones, and shales over the greater part of the area into soils, which as seen at the present time vary in texture, color, and other physical properties, either by reason of the character of the original material or because of the processes of decomposition and deposition that the modified soils have undergone. In the Morton area the character of the original rock has doubtless determined in a large measure the nature of the residual soils of the area. The soils of different textures occur alike on the steep rolling hills and the more level valleys, and the forces of modification have been practically the same. There are, however, differences between the soils of this area and those of the humid regions, due to difference in the processes to which they have been subjected, which it is well to note in this connection. In a humid region the rocks, subject to much rain and moisture, decompose more rapidly, so that the soil extends to a great depth, but as we go into the regions which have had a more scanty rainfall for ages we find, as in the Morton area, that the well-decomposed soil material is of shallow depth, and soon passes into the less thoroughly decomposed rock, and the materials which have broken show evidence that disintegration rather than decomposition has been the chief agency in their formation.

In the humid region, when the rocks are broken down into soil, the easily soluble alkali salts are rapidly removed, so that they are never a source of danger, nor are they even noticeable; but in a region of moderate rainfall like the Morton area, with rocks containing much soluble salt, as the Laramie formation, decomposing and setting free these salts, and with waters strongly impregnated seeping out of the coal beds upon the lower land, it is not surprising that alkali is found upon the surface and in excess in the soil. In the Morton area these alkali spots are of small extent and will never be a source of danger more

than at present, but some of them, locally known as "gumbo spots," occurring in cultivated fields, are a source of much annoyance to the farmers.

In the Morton area we have a series of soils derived from the weathering of the rocks of the Laramie formation, known as the Morton series. The Morton fine sand and the Morton fine sandy loam are the more sandy members of the series, derived from the coarser rocks of the Laramie, and the Morton loam is derived from the very calcareous silty member of these rocks, while the Morton clay loam and the Morton clay come from the finer textured rocks, ranging from fine shales to shaly clays. The Morton stony loam occupies those localities where portions of the rock have withstood weathering, and the fragments of broken rock are scattered over the surface, or more often, where bodies of chert have been left in the soil or on the surface where the less resistant sandstones and shales have broken down. The Morton gumbo is an alkali soil of low agricultural value. It occurs where the carbonaceous shales outcrop to form soils or where they immediately underlie the surface.

The alluvial deposits of the area owe their origin to the materials brought down and distributed by the streams in times of overflow. These processes are still adding to the soils of the lower bottoms, but the higher terraces are now above the limits of the floods. Along the smaller creeks the flood-plain soils closely resemble the upland materials, from which the stream has derived its sediments. For instance, along Timber Creek the lowlands are covered by very sandy soils, while along the larger creeks, which have gathered their sediments over large areas of widely varying materials, the soils, separated by the assorting action of the stream currents, range from very sandy loams to heavy clays. The alluvial soils include the Wade fine sandy loam, the Wade loam, the Wade silt loam, and the Wade clay.

The following table gives the name and extent of the several soil types shown in the accompanying map:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Morton loam	163,456	46.9	Wade silt loam	3,136	0.9
Morton fine sandy loam	96,384	27.7	Morton fine sand	1,280	.4
Morton stony loam	47,232	13.6	Morton clay loam	1,152	.3
Wade fine sandy loam	12,608	3.6	Morton clay	704	.2
Wade loam	8,576	2.5	Wade clay	576	.2
Morton gumbo	8,448	2.4			
Rough broken land (Bad lands)	4,672	1.3	Total	348,224	

MORTON FINE SAND.

The Morton fine sand consists of 10 inches of a very fine silty sand of light-brown color, underlain by a fine silty sand of lighter color, which usually contains more silt. The soil is loose and incoherent and carries very little organic matter. The subsoil at a depth of 3 feet or less passes into the partly altered sandstone from which it has been derived.

The Morton fine sand is the most sandy member of the soil series derived from the weathering of the Laramie rocks. It owes its origin to the coarseness of the original rocks and to its position, which has allowed the removal of the finer materials as they were released by the decomposition of the rock.

The soil occupies the flat tops and in places the slopes of a few high hills or buttes. Its sandy nature and topography render it unable to retain moisture, so that the areas have a very low agricultural value. It has, however, considerable value for grazing. While the grasses on these sandy hills are not so rank as on some of the heavier soils, they are of the most nutritious varieties.

The following table gives the results of mechanical analyses of the Morton fine sand:

Mechanical analyses of Morton fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17604	Soil	3.0	1.1	0.4	5.6	33.6	52.1	4.4
17605	Subsoil	.3	.3	.2	3.2	46.0	47.7	2.7

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17604, 12.80 per cent; No. 17605, 18.70 per cent.

MORTON FINE SANDY LOAM.

The Morton fine sandy loam consists of a brown fine sandy loam to an average depth of 18 inches, underlain by a fine sandy loam usually lighter in color.

The soil is slightly coherent, especially where organic matter is present in some quantity, has a loamy character, and does not break up under the plow into a loose, sandy condition. The subsoil, which usually contains more silt than the soil, becomes more silty in texture and lighter in color at lower depths.

The Morton fine sandy loam is one of the most extensive soil types of the area, being found throughout the region where the Laramie sandstones have weathered. It occurs in all parts of the upland of the Morton area in strips and spots of various sizes. It may occur as small areas covering a single hill or as extensive stretches including many square miles. As a rule, however, the hills and rolling sections are more likely to be sandy than the level land.

The entire area covered by this type is well drained and a large portion of it is excessively drained, so that regular farming on the very sandy rolling land will be very uncertain in dry seasons. Where the land is not hilly good crops will be grown on this type in seasons of average rainfall.

The Morton fine sandy loam is derived by weathering from the more sandy rocks of the Laramie formation. This being a region of moderate rainfall, weathering has not taken place to any great depth. In some places hard sandstone is encountered at less than 3 feet below the surface, and such areas are of doubtful agricultural value. In other places the rock may have decomposed into soil to a depth of 10 to 20 feet, but the average depth at which the altered sandstone is struck is not far from 4 feet. Occasional stone fragments are found over nearly all areas of this type, being either portions of the sandstone that have resisted weathering or bodies of chert that were distributed through the original rock.

The Morton fine sandy loam is a very productive soil, and when well watered all the crops suited to the region may be grown upon it with success. Where there is rock near the surface or where the subsoil is very sandy and unsuited to retain moisture, it is unwise to depend upon the cultivated crops for a living, but such areas may be utilized for stock farming in connection with better soils. The whole of the Morton fine sandy loam is well adapted to grazing, having in its unbroken state a good growth of native grasses. The portions of the type now under cultivation produce good crops of flax, oats, and potatoes, and fair yields of wheat. The texture of the soil adapts it to truck crops and vegetables that require a rapid growth during a short season. For this reason it is better adapted to corn than are some of the other soils, but the possibility of injury from drought is greater than in the heavier soils.

The following table shows the results of mechanical analyses of typical samples of the Morton fine sandy loam:

Mechanical analyses of Morton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
16979	Soil	0.0	2.3	7.3	44.7	14.0	24.3	7.2
16980	Subsoil	.1	2.4	8.5	45.3	13.7	22.1	7.7

MORTON LOAM.

The Morton loam is the most extensive and the most valuable of the upland soils of the Morton area and the one upon which its future agricultural prosperity depends. To a depth of 18 inches the soil is a brown loam, with a large percentage of silt, and passes in many places into a silt loam. The subsoil where typical conditions prevail is a light-colored, almost white, silt loam, which usually extends

without change to a depth of more than 40 inches. The Morton loam is found over nearly the whole of the upland portion of the area. The most valuable stretches of this type for farming are some of the broad valleys, but the soil is not confined to this topography, extending as well over the rolling hilly country and in some cases covering rounded hills that stand above areas of more sandy soils. The townships that have the best farming land of the area are largely covered by this type of soil. Large tracts are found in several townships comprising broad valleys, among them T. 131 N., R. 87 W., and T. 132 N., R. 92 W., have the largest proportion of good farming land of this soil.

The Morton loam is derived from the very calcareous sandstones of the Laramie, which break down into a silty mass but finally weather into a silty loam soil. Drainage is naturally good—a result of the open texture of the subsoil and of the topography. On the other hand, the texture and structure of the soil enable it to retain moisture well, and this feature will greatly enhance its value over the fine sandy loam when dry years come.

The Morton loam, especially the well-situated level portions, was eagerly seized by the first homesteaders, and now practically every quarter section that contains enough of the soil for a farm has been entered. The early homesteaders have now had two crops and the success for these years has been very encouraging. Wheat, flax, oats, corn, and millet have been successfully grown and yields have been good. As much of the land has been put into cultivation for the first time and in most cases a sod crop was planted, the capacity of the soil has not yet been determined. It has been clearly demonstrated that it is a strong soil, suited to all the ordinary field crops of the area, and that there are no especial difficulties in the way of cultivation. All the crops enumerated have given good yields, and vegetables for home use, such as potatoes, cabbage, peas, and root crops, may be grown to perfection. With reasonable caution and the practice, as far as possible, of the dry-farming methods, there is no reason why the farmer on this type of soil should not make a success.

There are two exceptions to the general excellence of the Morton loam that must be noted. In some of the areas mapped as Morton loam, while the soil is typical, it covers rolling hills and in some cases contains much stone. Another phase is the rather unproductive portion of this type about the center of T. 132 N., R. 89 W., and in T. 131 N., R. 92 W., which approaches "gumbo" in character. These lands have been recognized by the new settler and avoided. They are especially undesirable in droughty years. Where the lignite or the strata containing much soluble salts do not come too near the surface, the unproductiveness is caused by surface accumulations of alkali, the effects of which will readily disappear under cultivation, but too much caution can not be exercised in taking up these lands.

In a native state the Morton loam is covered by a luxuriant growth of excellent range grasses and the type constitutes the best grazing land of the area. Some of the rougher land of the type is especially good pasture. The grass grows high enough to make a good yield of hay and all the smoother areas of the soil are mowed.

The following table shows the texture of typical samples of Morton loam:

Mechanical analyses of Morton loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17009, 17595, 17597.	Soil.....	Tr.	1.0	2.1	20.5	11.1	46.0	18.7
17010, 17596, 17598.	Subsoil.....	0.1	.9	2.3	12.6	5.8	50.5	27.7

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17596, 16.38 per cent; No. 17598, 26.88 per cent.

WADE SILT LOAM.

The Wade silt loam is one of the most desirable types of soil found in the Morton area. It consists of a brown silt loam having an average depth of 18 inches, underlain by a gray to yellow silt loam, usually containing about the same percentage of silt and slightly more clay. The Wade silt loam has a large accumulation of humus, which gives the dark color to the soil and the loamy character that makes it easily tilled. It differs from the silt loam of the upland in being of alluvial origin and in having more organic matter.

The Wade silt loam is found in several tracts, most of them in the eastern half of the area. They occur in high valleys in the upland, which show evidence of having been poorly drained before the stream channels were as well established as they are at the present time.

The areas of Wade silt loam usually lie well for farms, being gently sloping and well drained. A considerable portion of the type is cultivated, as it is a favorite type of soil with the homesteader and was one of the earliest to be settled. The soil is very productive and withstands drought well. Wheat, oats, flax, barley, corn, and millet are grown. It is well adapted to any of the usual field crops. The average yield of wheat is 25 to 30 bushels per acre.

The following table shows the composition of a sample of the soil and subsoil:

Mechanical analyses of Wade silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
16981.....	Soil.....	0.0	0.5	0.3	7.4	10.3	62.1	19.5
16982.....	Subsoil.....	.1	.5	.4	7.7	11.9	58.3	21.0

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 16982, 6.31 per cent.

MORTON CLAY LOAM.

The surface soil of the Morton clay loam is a heavy silty clay loam to an average depth of 16 inches, containing sufficient humus to give it a dark-brown color. The subsoil is a heavy silty clay loam of light color passing into a light-colored very silty clay and in some cases into a mass of almost pure silt. While the top soil is in some cases nearly as heavy as that of the Morton clay, the subsoil does not pass at lower depths into the shaly clay of the latter type.

The Morton clay loam, on account of its limited area, is a comparatively unimportant soil. It covers numerous small areas, many of them less than 2 acres in extent and too small to indicate on the map. There are two areas that are nearly 1 mile in width, but the total area is only 1,152 acres. As a rule it occupies small, rounded hills or knolls or in some cases slopes of such hills. The type owes its origin to the outcropping and weathering of the finer-grained calcareous rocks of the Laramie. The difference in texture between this soil and the Morton clay is probably due to a difference in the character of the original rock.

Not enough of the Morton clay loam has been brought under cultivation to judge by observation of its productiveness, but from its native vegetation it may be inferred that it has great value for certain purposes. The presence of the soil in the field may be detected by the luxuriant growth of grass which everywhere covers it. It is without doubt the most valuable grazing land of the Morton area, although its small extent lessens its adaptability for this purpose. Wheat and timothy should flourish, and all crops should resist drought on this type of soil.

The following table shows the results of mechanical analyses of typical samples of the Morton clay loam:

Mechanical analyses of Morton clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17599.....	Soil.....	0.1	1.3	0.6	5.0	11.8	52.9	27.4
17600.....	Subsoil.....	.0	.5	.3	2.6	6.8	61.5	27.8
17601.....	Lower subsoil..	.1	.7	.2	2.0	9.1	59.5	28.4

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17601, 4.36 per cent.

MORTON CLAY.

The soil of the Morton clay is a brown clay or silty clay ranging in depth from 6 to 15 inches. The subsoil is a heavy silty clay of gray to brown color, usually passing into drab shaly clay at less than 40 inches. The surface soil puddles when wet and when dry is intersected with cracks. The soil is naturally impervious and difficult to till.

The Morton clay is an unimportant type, being confined to a few small areas of sufficient size to indicate on the map, which accompanies this report; but numerous small patches from a few rods in diameter up to 5 acres occur throughout the areas of Morton loam. It usually occupies small knolls and hillsides where rapid erosion has exposed the shales. This soil is the heaviest member of the Morton series and is derived by weathering from the beds of fine shales which occur throughout the Laramie formation in this region. It is a product of the imperfect weathering of these shales, and the partially decomposed rock not yet converted into soil is usually found at no great depth. As a result of the decomposition of the shales, which in nearly all cases contain more alkali than the sandstones, and the impervious nature of the resulting soil, which has retarded the rapid removal of alkali from the soil, areas of this type nearly always show indications of injurious soluble salts. To such an extent have these salts accumulated at the surface that the grass is often sparse on these areas, and spots several feet in diameter are bare, when a luxuriant growth of grass should be found on a soil so well suited by texture to short-rooted plants. These accumulations of alkali, however, are not so great as to be detrimental to cultivated crops, for in most instances when the land is plowed and the surface accumulation of salt is mixed to a depth of several inches, there will not be further trouble on account of alkali.

None of the small areas of Morton clay are at the present time under such conditions of cultivation as to indicate the agricultural possibilities of the type. By texture, however, the soil is well adapted to grasses and the cultivated varieties, such, for instance, as timothy, should do well. It is well suited to wheat and flax, which no doubt for a long time will be the principal crops on all types of soil in the area.

The following analyses show the texture of samples of the Morton clay:

Mechanical analyses of Morton clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17593	Soil	0.0	0.9	0.5	4.2	3.0	48.9	42.0
17594	Subsoil	.3	.7	.3	3.4	4.4	47.9	42.7

MORTON STONY LOAM.

The term Morton stony loam refers more to the stony condition of the surface soil than to the texture of the finer earth composing the true soil, and it is applied to areas which contain in the soil or have scattered over the surface such quantities of stone fragments as to make them unsuitable as farming land. The quantity of stone varies greatly in different localities, but from 15 to 50 per cent is commonly

found. The stone may consist of sandstone, chert, or glacial bowlders. On the higher hills the sandstone and sandy shales, where exposed by rapid erosion, break down and the more resistant portions remain as fragments scattered over the surface or embedded in the soil. By far the greater part of the stone is chert, which was originally embedded in the parent rock, but in the general down-wearing of the country it has been left on the surface in the form of more or less rounded bowlders, which range in size from small gravel to masses weighing many hundreds of pounds. The quantity of chert present in any one locality is dependent upon the quantity contained in the original rock and the extent of the subsequent erosion which has set free the cherty bodies. Another source of the stone content, which is comparatively of small importance over the Morton area, is the glacial drift. Hills covered by glacial bowlders may be seen in the northeastern corner of the area, north of Wade. As a rule these deposits are of limited extent on the tops of the higher hills, and consist of smooth bowlders and gravel from the smallest size to a foot or more in diameter. Occasionally on these hills and scattered over part of the area are large bowlders of granite and other igneous rocks, several feet in diameter and weighing many tons.

The interstitial soil material in these stony tracts may vary widely in texture. In view of the undesirability of these lands for cultivation, it was not considered advisable to subdivide these areas on the basis of texture. As a general rule the stony land is of a sandy nature, and disregarding the stone content it much resembles the Morton fine sandy loam. This is nearly always the case where the stone consists of sandstone. There are, however, areas where the fine earth ranges from a silty loam to a heavy loam, and this is more likely to be the case among the chert bowlders.

The Morton stony loam occurs in irregular areas over the entire region. There are very few square miles entirely free from these stony tracts, many of which are too small to be indicated in a map of the scale used. Large areas of extremely stony land may be expected among deeply eroded hills. The most remarkable development of the chert-covered hills may be seen in Pretty Rock Buttes and some of the hills in the vicinity. Here the intervening areas are so thickly strewn with masses of chert fragments that it is difficult to set foot without touching a stone.

The stony land is not uniform in character, and narrow winding valleys of tillable land occur throughout the rocky hills. It was not possible to outline these valleys on a small scale, but in many cases they furnish room for a house and small fields for those who occupy the hills in order to graze their cattle and thereby greatly enhance the value of the rough land. Such tracts may be utilized to raise winter feed for the cattle and supplies of potatoes and vegetables for the use of the rancher.

WADE FINE SANDY LOAM.

The Wade fine sandy loam to a depth of 36 inches is a fine sandy loam with no marked variation in texture between soil and subsoil. The surface 8 inches, however, is usually darker in color, due to its larger content of humus. As in the case of the other alluvial soils in the Morton area, there is no uniformity in the texture of the Wade fine sandy loam over any considerable areas, even in the same stream bottom. Thin beds of heavier and lighter material may alternate throughout a 3-foot section, but the general average of texture for this type of soil is that of a fine sandy loam. On some of the higher terraces the soil closely resembles the Morton fine sandy loam, and where the two types are contiguous it is often difficult to determine their boundary lines.

The Wade fine sandy loam is the most sandy member of the soil series found along the streams of the Morton area. It borders the Cannon Ball River in broken strips and with frequent variations in texture, the most sandy tracts occurring in the lowest levels in the southeastern part of the area. The type occurs along some of the small streams. Timber Creek, in the western part of the area, is bordered by the largest bodies.

The lower flood plains of the Cannon Ball are subject to occasional overflow, but the flood waters quickly subside and none of the type lacks drainage.

The Wade fine sandy loam is derived from the sediments deposited by the streams in times of overflow. The streams gather their sediments from the upland soils of the Morton series, and the assorting action of the stream currents have separated the different grades of sand, silt, and clay, and deposited them as soils in their present positions.

A large part of the Wade fine sandy loam is now under cultivation. Oats, flax, millet, and corn, and to a lesser extent wheat, are grown with profitable results. The lower terraces will produce good crops in seasons when crops on the uplands suffer for lack of rain. The type is well adapted to alfalfa, but so far it has not been tried. Heretofore the most successful and most profitable crop has been oats. All kinds of vegetables and truck may be produced in large quantities when there shall arise a demand for such products. At present they are grown by the ranchers for home use.

The following analysis shows the textural composition of the Wade fine sandy loam:

Mechanical analysis of Wade fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
16983.....	Soil.....	0.0	0.9	3.5	42.0	20.1	24.2	8.5

WADE LOAM.

The Wade loam is, after the Wade fine sandy loam, the most extensive of the alluvial soils of the area. Like the Wade fine sandy loam, it is not uniform over any considerable areas. The average texture of the type is a loam of high silt content with a depth of 8 inches. In color it ranges from a light to a dark brown in the case of the soil, with a subsoil of lighter color.

The Wade loam is found in narrow strips along Cannon Ball River and many of the smaller streams, and has a total area of 8,576 acres. It usually occupies the lower terraces of the streams, many of them subject to overflow, but in some cases the type occurs on older terraces now above the limit of flooding. As a rule, the flats or bottoms covered by the Wade loam are either level or very gently rolling, but drainage is nearly always adequate for farming purposes. Wherever conditions are favorable there are accumulations of alkali salts in the lower flats.

The Wade loam is the most desirable of the alluvial soils from an agricultural standpoint. The soil is retentive of moisture and advantageously situated for purposes of general farming and especially well located for stock raising. Wheat, flax, and oats are the principal crops, with some corn and millet grown for feeding purposes. The soil is also adapted to alfalfa where the drainage is good.

The following table gives the results of mechanical analyses of a sample of the soil and subsoil of the Wade loam:

Mechanical analyses of Wade loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17606	Soil	0.1	2.5	2.0	17.4	8 0	52.8	17.7
17607	Subsoil	.3	5.0	4.9	27.6	14.0	36.1	12.2

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17607, 1.91 per cent.

WADE CLAY.

The Wade clay is the heaviest alluvial soil of the area. It consists of a brown to nearly black clay to an average depth of about 6 inches, underlain by a brown to dark-drab heavy clay to a depth of more than 36 inches. The large percentage of organic matter imparts the dark color to the soil.

The term Wade clay has been made to include the clays deposited along the streams and the soils which have been deposited in depressions in the upland, many of which are now parts of stream valleys but at a former time were low areas without well-established drainage. This soil is usually washed from the clay or shale areas of the upland, and in many cases comes in contact with the Morton

clay and resembles it so closely that the only basis of separation is one of origin.

None of the Wade clay is yet in cultivation, but it is a productive soil, and aside from the difficulties of tillage it should be very desirable farming land. The small areas of the type make excellent hay meadows, and hay has been mowed from them by the cattlemen for a long time.

The table given below shows the texture of the Wade clay:

Mechanical analyses of Wade clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17589	Soil	0.0	0.9	2.2	7.0	11.0	42.4	36.7
17590	Subsoil	.0	.4	1.8	4.4	7.0	60.9	25.2

MORTON GUMBO.

The Morton gumbo represents a condition rather than a definite soil type. Mention has been made of the lignite strata that occur through the Laramie and the carbonaceous alkali shales which are associated with the lignite beds. The outcropping and subsequent weathering of these materials have given a condition typical of the entire Morton series over the southwestern part of North Dakota.

The actual soil texture may vary, but the appearance and agricultural value of all of these areas of Morton gumbo is the same. In general, the surface soil is a gray silty loam to an average depth of 6 inches. The subsoil is a gray loam of lighter color and larger silt content. In some areas of this type, however, the lignitic beds may underlie the surface at a depth less than 3 feet. In very few cases can perfect lignite be found over such areas, but very often the black carbonaceous strata are encountered. The surface soil is, as a rule, heavier than at a depth of a few inches, but the puddling of the clay on the surface gives the appearance of a much heavier soil than really exists below the surface crust. All areas of the soil are extremely silty, there being in most cases 50 to 60 per cent of silt in the soil, and 60 to 65 per cent in the subsoil. The clay in both soil and subsoil ranges from 20 to 30 per cent.

The characteristic feature of the Morton gumbo is its present unproductiveness, due to the large amount of injurious alkali salts in the soil. The term "gumbo" is used by the average farmer to designate any spot which is unproductive by reason of alkali. The farmer has learned by experience that unproductiveness is associated with a heavier soil; hence land containing spots of loam or clay with sparse vegetation is avoided.

The Morton gumbo occurs in detached bodies of various sizes throughout the area. Where the carboniferous shales outcrop upon a broad, flat valley, or immediately underlie the surface, stretches of the type of several square miles in extent may result. Frequently the soil occurs as strips along the streams where erosion has exposed the shale. Over a large part of the area small spots of it may occur in cultivated fields, causing much annoyance to the farmer.

The type is not confined to any particular topography. It occurs on sloping hillsides and over level flats. The surface features and vegetation are characteristic. The unproductiveness does not extend over the whole of the areas, but occurs in spots with narrow strips of good land between. Where the spots are so infrequent as not seriously to impair the agricultural value of the land, the areas have been included with other types, and only those areas have been indicated on the map as Morton gumbo that are of large size and so unproductive as to be of little value for farming. Another characteristic of the type is the roughness of the land, due to the settling of the ground or, on slopes, to landslides. The vegetation is also characteristic, consisting, in the alkali spots which are not entirely bare, of cactus, sagebrush, and other salt-resisting plants. The spots entirely bare rarely exceed a few feet in diameter, except where the lignite beds outcrop. The strips free from injurious salts support a growth of good pasture grasses, so that nearly all of the "gumbo" flats have value as grazing land.

One phase of the land mapped as Morton gumbo deserves mention. Along Cannon Ball River and some of the smaller streams strips of the type as mapped are not entirely of residual origin, but are wholly or in part the washings from the "gumbo" areas on the hillsides. As this phase nearly always comes in contact with the typical "gumbo," and as there is no great difference in the two, it was not considered practicable to separate them.

Any analysis, chemical or physical, of the Morton gumbo, can show very little, owing to its variations, but the table given below shows the texture of a sample of the type:

Mechanical analyses of Morton gumbo.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17006.....	Soil.....	0.0	0.3	0.8	13.3	3.6	60.3	22.0
17007.....	Subsoil.....	.0	.4	1.6	5.5	.6	60.5	32.1
17008.....	Lower subsoil...	.0	.3	1.1	7.1	1.7	66.0	23.6

ROUGH BROKEN LAND (BAD LANDS).

Throughout the western part of North Dakota, where the bed rock is chiefly the sandstone of the Laramie formation and where these rocks have been subject to rapid erosion by the streams, a typical

topography has been developed. On account of the extreme roughness of these tracts and the difficulty of crossing them, they were called by the early French explorers "Bad Lands to Travel Through," which has since been shortened to "Bad Lands," by which name they are now generally known. Although the Morton area is far to the east of the Bad Lands proper, small areas of badly eroded hills occur, to which the name has been applied.

The Bad Lands are sharp rugged hills, sometimes devoid of vegetation but more often partly grassed over. Many of the hills have the butte or mesa form—a flat top covered with grass and steep sides commonly bare. Many slopes are extremely rough and cut by numerous gullies and ravines. Narrow, winding, level valleys may occur throughout the Bad Lands, covered with good grasses or so affected with alkali as to support no valuable vegetation.

The extent of Bad Lands in the Morton area is only a few square miles, the largest area lying west of Wade. The narrow strips in the other parts of the area indicate the line of steeply eroded, rough, bare bluffs that mark the descent from the upland to valleys below.

The Rough broken land is by no means without agricultural value, for it has always been highly esteemed as a grazing ground by the cattlemen. Water and good grass are to be found here and the high bluffs afford protection from winter storms. At the present time these lands have an additional value for the rancher who depends entirely upon grazing, for in the Bad Lands he will never be disturbed by the homesteader.

SUMMARY.

The Morton area is situated in the southern part of North Dakota and west of the center of the State. It lies wholly within the drainage basin of the Cannon Ball River. The region as a whole is a high plateau, the surface of which ranges from gently rolling to rough and hilly.

Until within the last two years the only settlers were occasional ranchers who grazed horses and cattle on the public lands, but there has recently been a rapid immigration, so that now all public land suitable for farming has been taken for homesteads, though there are as yet no towns or railroads.

The climate of this part of North Dakota is subject to high summer and low winter temperatures. The atmosphere is dry and healthful. The snowfall is usually light and cattle graze over the hills throughout the winter. An average of about one hundred and twenty days each year free from frost gives a growing season of sufficient length for the maturity of the common crops of this region.

The question of rainfall is one of great importance to this area. The average rainfall is sufficient, if well distributed throughout the growing season, to produce good crops. Occasional dry years may be expected, but with proper care and the practice of the best methods

of dry farming there is no reason why the farmer in this area should not be entirely successful.

The conditions prevailing in the Morton area are those of a newly settled country, and not much advancement has yet been made in agriculture. Sod crops of wheat, flax, and oats were put in by the settlers and the results have been encouraging. All hay, oats, and potatoes produced have found a ready local market. Cattle and horses are still raised in large numbers by the ranchers and many large flocks of sheep are found in the area.

The soils of the Morton area fall into two principal series—the Morton series, the soils of which have been derived by weathering from the sandstones and shales of the Laramie formation, and the Wade series, which consists of the same soils reworked and redeposited by stream action. The most important soil of the upland Morton series is the Morton loam, which comprises the greater part of the safe farming land of the area. It is very productive, retentive of moisture, and easily tilled. In average seasons it produces large crops of wheat, flax, and oats. The Morton fine sandy loam, while not so retentive of moisture as the Morton loam, is over a large part of the area a good farming soil and for many years it has produced a good average of profitable crops. The stony areas of the upland have been classed without regard to texture as Morton stony loam. It furnishes excellent grazing.

The soils of the Wade series, with the exception of the Wade silt loam, occur in narrow strips along the larger streams.

The Wade silt loam occurs in broad valleys in the upland, and its texture and humus content make it one of the most desirable soils of the area. The alluvial lands along the streams range in texture from very sandy loams to heavy clays, but only the Wade fine sandy loam and the Wade loam are of agricultural importance. The soils are adapted to a wide range of crops, but at present wheat, flax, and oats are grown.

The Morton gumbo occupies considerable areas in both the upland and in the stream valleys. It occurs on the outcropping of the lignite beds and the alkaline shales with which they are associated. This soil is difficult to till, but the greater part of it may be used for pasture. The Rough broken land (Bad lands) is a badly eroded country that has no value except for grazing, to which it is well adapted. There is only a very small proportion of the Morton area that is without some agricultural value, and the greater part of it is good farming land. The mixed farming and grazing land make this region especially suited to stock raising in connection with farming, and this mixed agriculture will in the end be found more profitable than the growing of farm crops exclusively.

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SOIL MAP
NORTH DAKOTA
MORTON SHEET

U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

AGRICULTURAL AND ECONOMIC GEOLOGICAL SURVEY
OF NORTH DAKOTA
DANIEL E. WILLARD, DIRECTOR.

Scale 1 inch = 1 mile

SOIL PROFILE
(3 feet deep)

Morton stony loam — Fsl, Fsl
Morton fine sand — Fsis, Fsis
Morton fine sandy loam — Fsl, Fsl
Morton loam — L, L
Morton clay loam — Hcl, Hsicl
Morton clay — Sic, Sic
Morton gumbo — Sil, Sil
Wade fine sandy loam — Fsl
Wade loam — L, L
Wade silt loam — Sil, Sil
Wade clay — C, C

LEGEND

Fsl Fine sandy loam
Fsis Fine silty sand
Sil Silt loam
Hcl Heavy clay loam
Hsicl Heavy silty clay loam
Sic Silty clay
L Loam
C Clay

Soils surveyed by
Thomas D. Rice, assisted by Ray Babcock and J. T. Weaver
of the Agricultural and Economic
Geological Survey of North Dakota.
1907.

Field Operations
Bureau of Soils
1907.

LEGEND

Morton stony loam
Morton fine sand
Morton fine sandy loam
Morton loam
Morton clay loam
Morton clay
Morton gumbo
Wade fine sandy loam
Wade loam
Wade silt loam
Wade clay
Rough broken land (Bad lands)